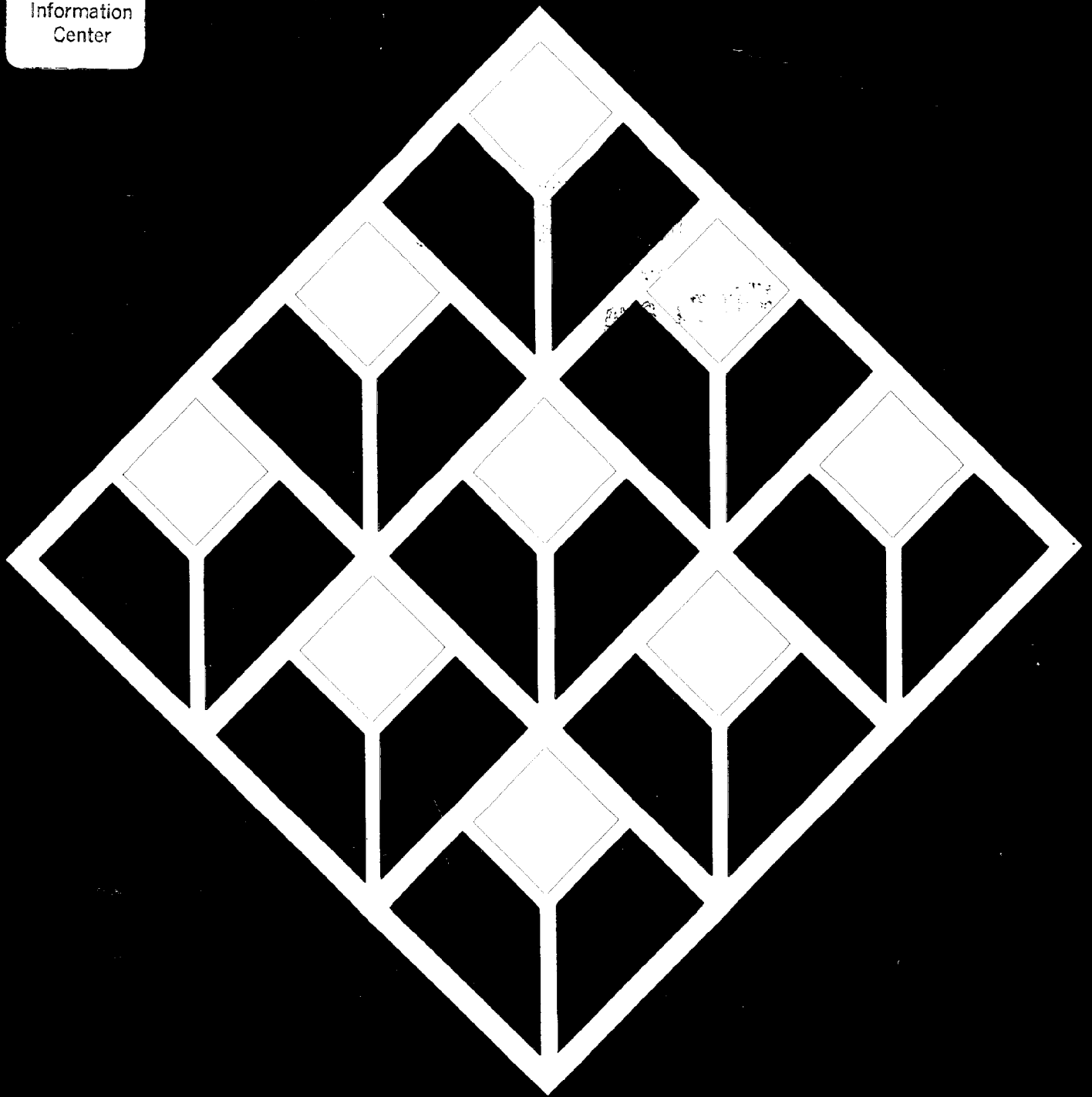


Coastal Zone
Information
Center



COASTAL VEGETATION OF DELAWARE

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Coastal Vegetation of Delaware, the Mapping of Delaware's Coastal Marshes. June 1973; DEL-SG-15-73; College of Marine Studies, University of Delaware, Newark, Delaware, 19711; This work is partially a result of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 2-35223.

COPY #2

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3/
COASTAL VEGETATION OF DELAWARE



The Mapping of Delaware's Coastal
Marshes

V. Klemas *et al.*

F. C. Daiber

D. S. Bartlett

O. W. Crichton

A. O. Fornes

21
College of Marine Studies
University of Delaware

March, 1973

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INTRODUCTION

The commitments to environmentally sound coastal land management that have been generated in federal and state governments over the past few years have produced a demand for accurate and complete bodies of scientific data on which to base policy decisions. Coastal wetlands in particular have been the subject of much controversy and litigation, and the lack of survey-type information over broad areas of wetland is apparent. Accurate maps showing the boundaries of tidal wetlands are required for the enforcement of existing coastal zoning laws, while more detailed information about tidal marsh environments is necessary if more comprehensive zoning is to be formulated in the future. For this reason a baseline mapping project was undertaken in Delaware's coastal wetlands as a prelude to an evaluation of the relative value of different parcels of marsh and the setting of priorities for use of these marshes.

In view of severe limitations of time and manpower, the mapping approach used relied heavily on aerial photography and multispectral analysis, utilizing conventional ground reconnaissance only to aid and check the photo-interpretation. Work such as that of Kolipinski¹, Garvin², Wobber³, and others has shown that multispectral image analysis can significantly help, yet not replace, the human interpreter. Suitable imagery from NASA and other sources was available, and access to General Electric's Multispectral Data Processing System was obtained.

Coastal wetlands of the type found along the entire East Coast of the United States are well suited to remote sensing techniques, particularly multispectral analysis. The uniform flatness of marsh topography eliminates variations in reflectance due to sloping surfaces and shadows. The most common marsh plant species are few in number, thus simplifying photo-interpretation. Environmental changes generally take place over large horizontal distances in the marsh; therefore zones of relatively uniform vegetation are usually large enough to be discernible even on very high altitude imagery. Finally, the major plant species are different enough in their morphologies to have distinct reflectance characteristics, particularly in the near-infrared portion of the spectrum. The net result is that multispectral imagery can be used to make detailed wetlands maps showing vegetation growth patterns which are related to local environmental factors.

DESCRIPTION OF DELAWARE'S WETLANDS

There are approximately 115,000 acres of tidal wetland in the state of Delaware, forming an almost continuous band along the western shore of Delaware Bay from Cape Henlopen north to Wilmington.⁴ The width of this band varies from a few hundred yards to three to four miles with an average width on the order of one mile. In addition, there are small fringes of marsh associated with the barrier beach-lagoon complexes along the Atlantic Shore in the southern portion of the state. The most abundant plant species found in the marshes are salt marsh cord grass (*Spartina alterniflora*), salt marsh hay (*Spartina patens*), spike grass (*Distichlis spicata*), reed grass (*Phragmites communis*), high tide bush (*Iva frutescens*), and sea myrtle (*Baccharis halimifolia*). There are, of course, many other species present but in most cases their occurrence is limited to small patches scattered within areas dominated by one or more of the above-mentioned primary species.

As previously stated, the major species display distinct morphologies allowing them to be distinguished from one another on the basis of reflectance characteristics. A brief description of the preferred environments, morphology and resulting reflectance of each species category follows.⁵

Major Categories:

1. *Spartina alterniflora* (Salt marsh cord grass).

The dominant marsh grass species of the Eastern United States, *S. alterniflora*, occupies the low or wettest portion of the marsh. Two ecotypes are distinguished in Delaware: a tall form which inhabits the borders of the tidal creeks and drainage ditches, and a short form found over great expanses of the remaining low marsh areas.⁷ The narrow stalks and leaves of *Spartina alterniflora* provide a relatively sparse reflecting surface when viewed from above with the result that this species appears darker than the other major species in color infrared imagery. (See Figure 2.) The tall form provides a slightly more dense reflecting surface than the short form, allowing discrimination of the two ecotypes.

2. *Spartina patens* and *Distichlis spicata* (Salt marsh hay and spike grass).

These two species occupy areas of marsh topographically higher than those occupied by *Spartina alterniflora*. Although short with thin stems, both species grow in a very dense mat which produces high reflectance in the infrared. (See Figure 2.) Often, but not always, the two species are found together and are indistinguishable on color infrared imagery. Because they appear to occupy very similar environmental niches, the two species are lumped together into one category.

3. *Phragmites communis* (Reed grass).

Naturally found in small patches on mounds and other topographic highs within the marsh, *Phragmites* now occupies extensive areas where artificial filling or drainage has produced a suitable environment. Growing up to ten feet high with broad leaves, *Phragmites* has the highest reflectance of any of the marsh grasses and thus appears lightest on the photos.

4. *Iva frutescens* and *Baccharis halimifolia* (High tide bush and sea myrtle).

These low shrubs are generally found in a narrow band just above the reach of the highest tides. They are frequently found together, and their broad leaves and sparse growth pattern combine to give them distinct reflectance characteristics in the infrared.

5. Fresh water impoundments.

Built to attract ducks and other water fowl, these areas are generally identified by their straight, artificial boundaries and the continuous presence of standing water. They contain many fresh water plants including species of *Peltandra* (Arrow arum), *Typha* (Cattail), *Pontederia*, and *Sagittaria* (Arrowhead).

It should be noted that these groups were identified on the basis of reflectance in three color bands (green, red and infrared) and not simply in the infrared as might be inferred from the general descriptions above.

MAPPING APPROACH

The primary imagery used in compiling vegetation maps was obtained by a NASA RB-57 aircraft in September of 1970 (Mission 144, Site 244). Of the various types of imagery available from Mission 144, it was decided that nine-inch color infrared photos would provide optimal discrimination of vegetation types. Visual interpretation was performed on color infrared prints obtained with a Zeiss RMK 30/23 camera at a scale of 1:60,000. (See Figure 2.) For automated analysis it was found that color infrared transparencies taken with a Wild Heerbrug RC-8 camera at 1:120,000 scale had better light characteristics and thus yielded better results despite the larger scale. Resolution in these high altitude photographs was sufficient to produce first generation vegetation maps registered onto U.S.G.S. topographic maps at a scale of 1:24,000 and for more detailed automated pattern recognition at considerably smaller scales. A more detailed second generation set of maps is being compiled from low altitude (11,500 feet) NASA imagery obtained in August, 1972.

To collect ground truth for the interpretation of the NASA photographs, visits to field sites on foot and by small boat were carried out throughout the summer of 1972. In addition, low altitude aerial photography was obtained from light planes. Taken from altitudes of 500 to 2,000 feet, this imagery was sufficiently detailed for easy identification of major plant communities and thus provided ground truth over larger areas than it was possible to obtain on foot or by boat. In some areas detailed field work, including measured transects, was used as a check of automated pattern recognition capabilities.

The classification scheme used in mapping developed naturally from the structure of the marsh plant communities and from the discrimination capability of the imagery used. Therefore, the five major categories described not only represent the dominant species and communities present in the marshes of Delaware, but also are the vegetation types which are most readily discriminated in the imagery used for interpretation.

In areas where a significant amount of another species than that shown as predominant in the NASA imagery was present, this is noted on the maps by capital letters. These were identified by field observation, although further studies may show that some such associations can be identified from aerial imagery.

In addition, mapping categories were established for areas ditched for mosquito control, and for marsh areas lost to dredge-fill operations after the most recent revision of the U.S.G.S. topographic maps. Marshes lost to development were easily identified on NASA imagery while Department of Agriculture photos at a scale of 1:20,000 (See Figure 3) were used to delineate ditched areas.

AUTOMATED ANALYSIS

While the discrimination and mapping of gross vegetation features are most readily accomplished by a human interpreter, detailed interpretation can benefit from the use of automated multispectral analysis. Such automated analysis was performed utilizing the General Electric Multispectral Data Processing System (GEMSDPS), which is an analogue-digital hybrid designed as an analysis tool to be used by a human operator and benefit from his observations.⁶

This accurate and highly flexible system has been designed to allow the operator to adjust the signature analyzer and other processing units for optimum discrimination and to see the results of these adjustments immediately. He can thus very rapidly combine his knowledge of the scene gained in the field with precise, unbiased electronic analysis and thereby measure the spectral characteristics of a region of any size in the scene; he can search the scene for regions with similar characteristics and read out the percentage of the total scene occupied by areas with the specified spectral signature. By repeating the same procedure for other areas in the scene, the operator can quickly produce a composite photo-map enhancing all of the spectrally classified areas of interest.

MAPS OF DELAWARE'S WETLANDS

The fifteen maps of Delaware's coastal zone which follow were prepared to show the dominant species or groups of species of vegetation present. Five such categories of vegetation are used indicating marshes dominated by 1) salt marsh cord grass (*Spartina alterniflora*), 2) salt marsh hay and spike grass (*Spartina patens* and *Distichlis spicata*), 3) reed grass (*Phragmites communis*), 4) high tide bush and sea myrtle (*Iva* species and *Baccharis halimifolia*), and 5) a group of fresh water species found in impounded areas built to attract water fowl. In addition, major secondary species are indicated where appropriate. Multispectral analysis and enhancement were performed on selected areas thought to be representative of the relative species abundance and growth patterns present in the surrounding marsh. The enhancements themselves, then, are small-scale inserts designed to supplement the generalized vegetation maps by showing detailed growth patterns and the relative abundance, in percentages of each species present. Figure 3b, for example, is an enhancement of the area enclosed by box #1 on the Little Creek quadrangle. Zonation of different vegetation species which could not be displayed on the large scale map is shown with *Spartina alterniflora* forming an outer fringe and *Spartina patens* occupying the higher, center portion of marsh. The original maps were at a scale of 1:24,000 registered to U.S.G.S. topographic and soil maps. Inserts show those areas which were automatically analyzed, and the results of that analysis, providing a general picture of Delaware's coastal vegetation and a detailed description of selected marsh areas.

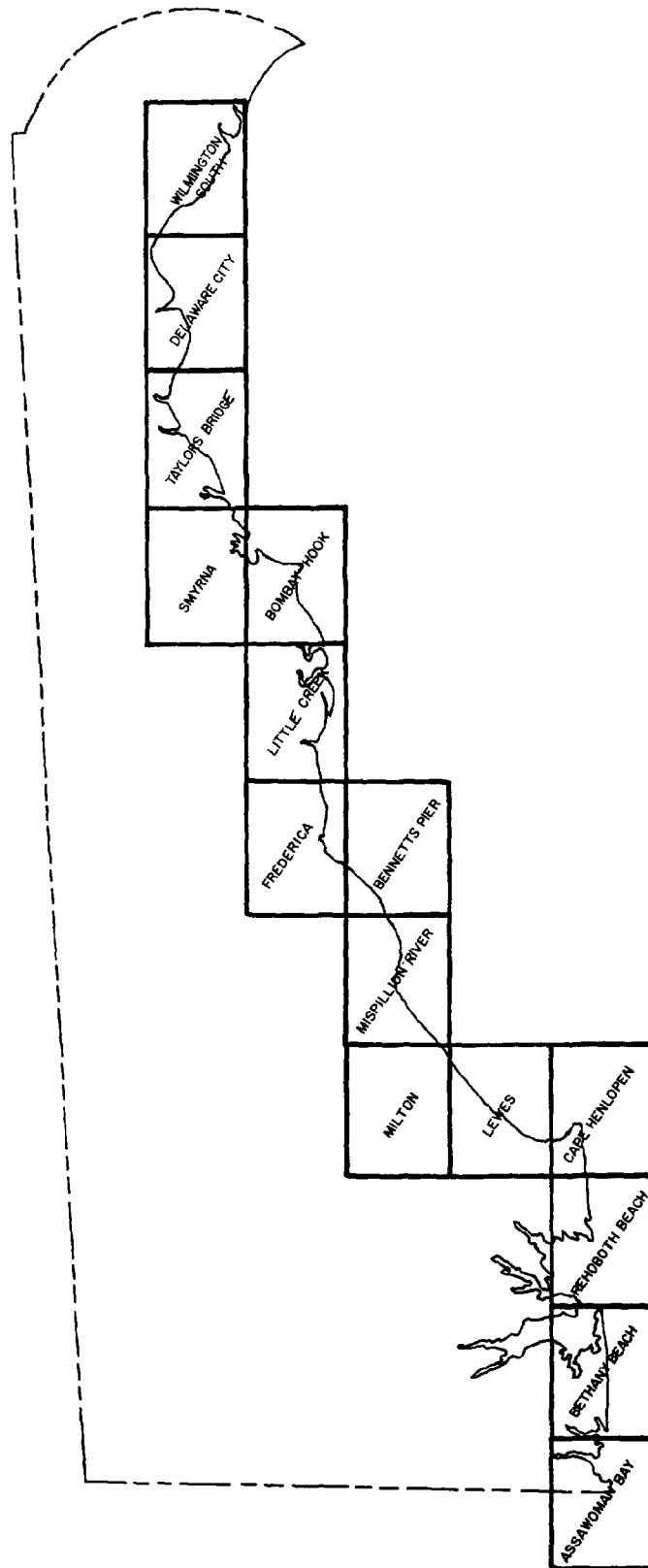
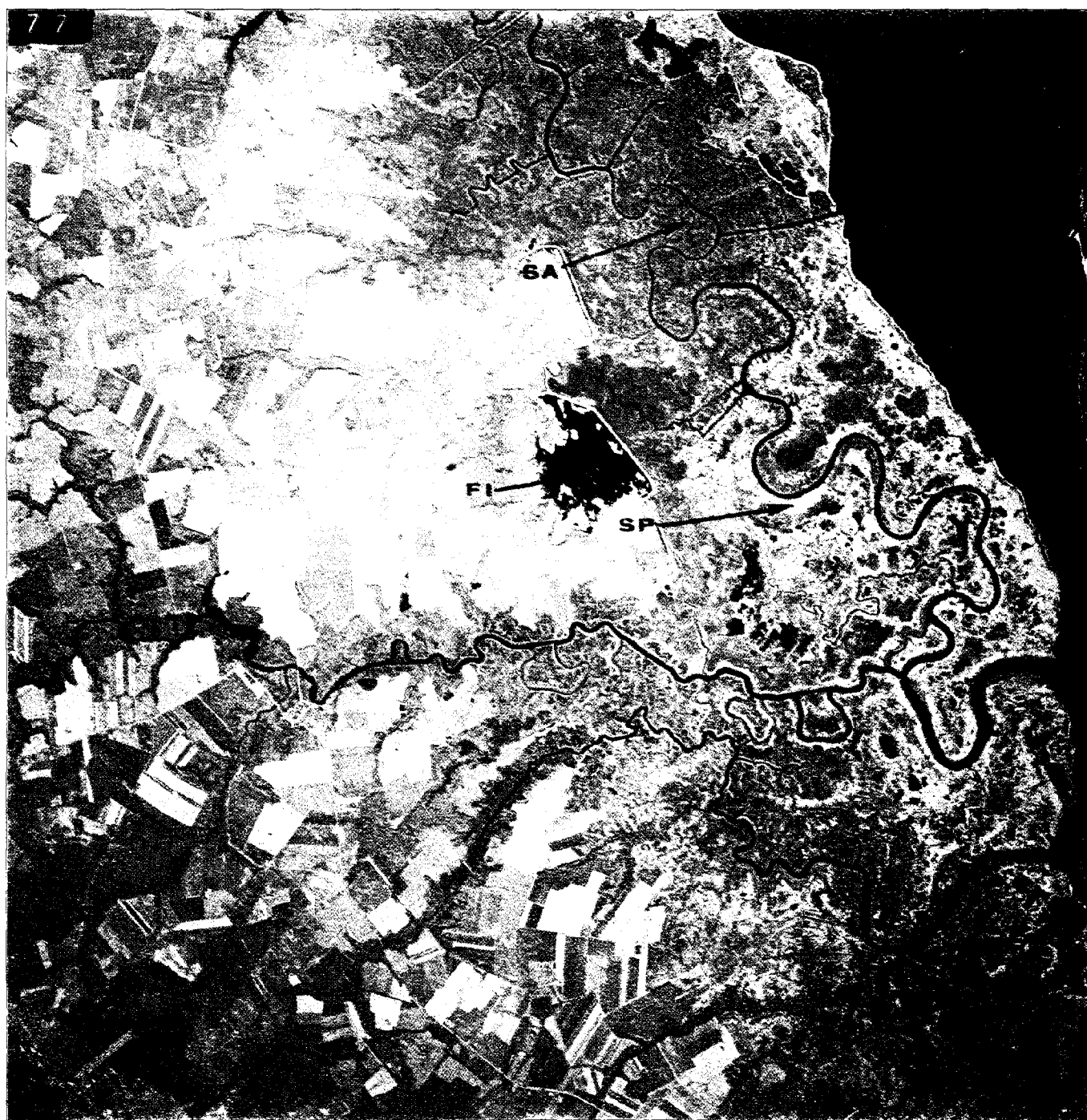


FIGURE 1

Index Map Showing
Map Quadrangles

FIGURE 2



Sample NASA-RB-57 Color-infrared Photograph

Original size 9" x 9"
Original scale 1:60,000

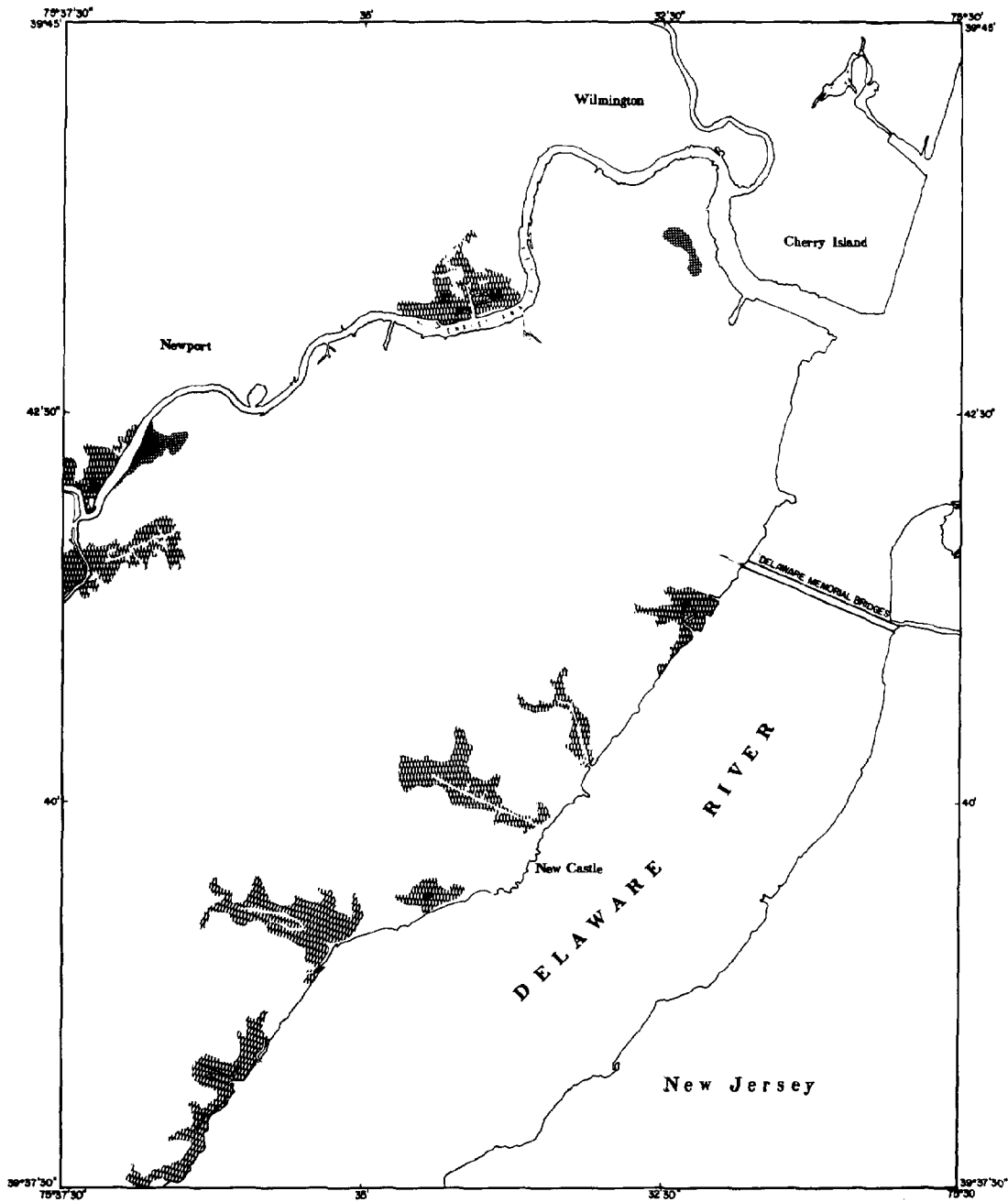
SA - *Spartina alterniflora*
SP - *Spartina patens*
FI - Fresh water impoundment



FIGURE 3

Sample: Black and White Dept. of Agriculture Photo

Original size 9" x 9"
Original scale 1:20,000



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (see *Fraxinus* and *Baccharis halimifolia*)
- S. *Scirpus* spp.
- M. *Halodule* spp.
- Z. *Zizania aquatica*
- W. *Acrida canaliculata*
- F. Fresh Water Category (*Potamogeton zosterifolius*, *Potamogeton cordatus*, *Typha* spp., *Sagittaria* spp.)



WILMINGTON SOUTH, DEL.

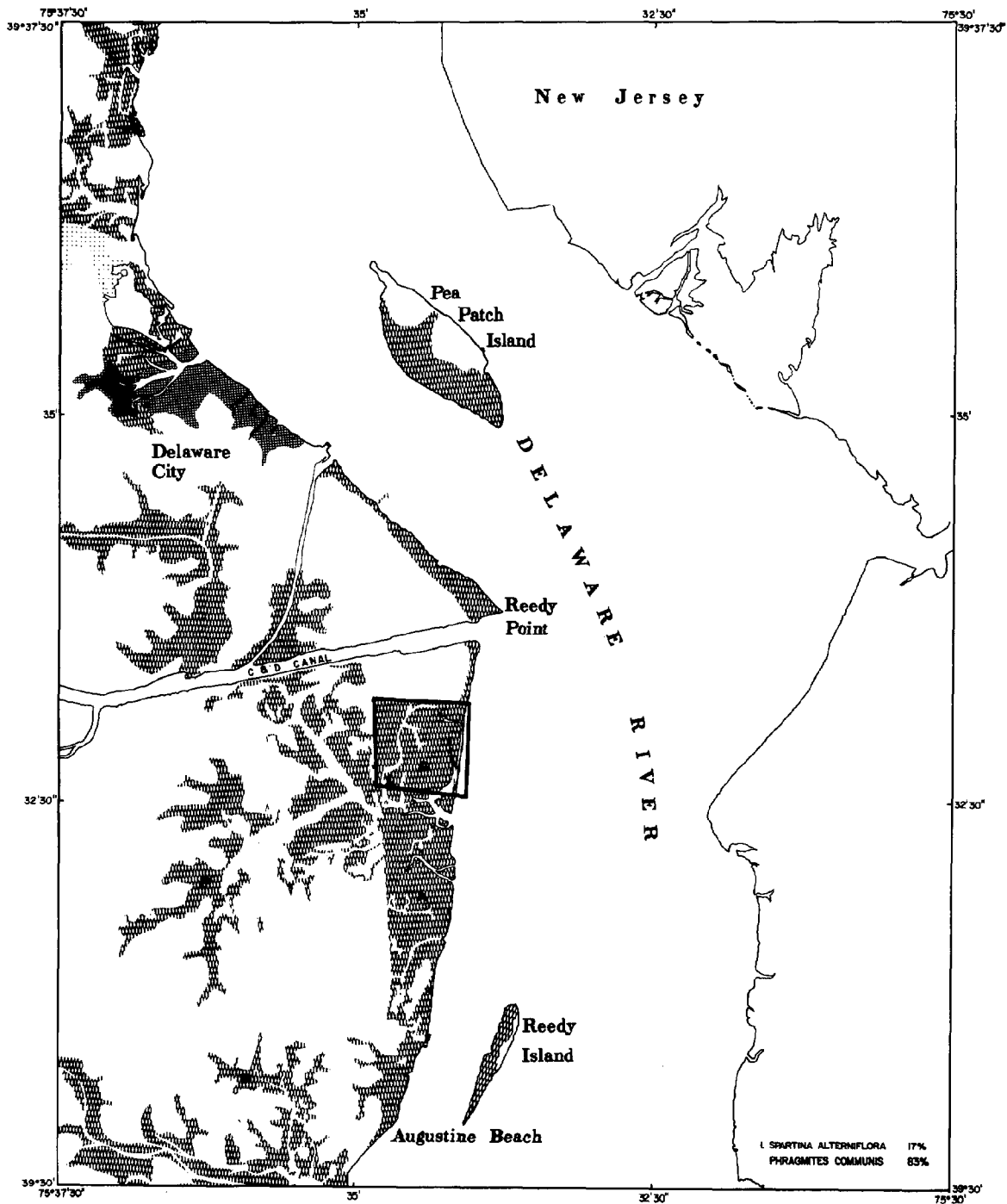


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series V-331, Potomac River, Virginia
 Vegetation Mapped and Published by the College of Marine Studies, University of Delaware, Newark, Delaware 19711
 1:50,000 scale (1 inch = 1 mile)

GRAPHICAL KEY OF DOMINANT SPECIES

- Phragmites communis* (Bird Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Fraxinus* and *Baccharis halimifolia* (Shrub)
- Scirpus* spp.
- Halodule* spp.
- Zizania aquatica*
- Acrida canaliculata*
- Fresh Water Category (*Potamogeton zosterifolius*, *Potamogeton cordatus*, *Typha* spp., *Sagittaria* spp.)
- Marsh loss to development and/or dredge spoil cover and topographic into terrain
- Mangrove Control District



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- T. Shrubs (*Iva frutescens* and *Baccharis palmifolia*)
- S. *Scirpus* spp.
- M. *Muhlenbergia* spp.
- Z. *Zizania aquatica*
- W. *Arundo donax*
- F. Fresh Water Category (*Peltandra virginica*, *Potamogeton nodosus*, *Lythrum* spp., *Sagittaria* spp.)



DELAWARE CITY, DEL.

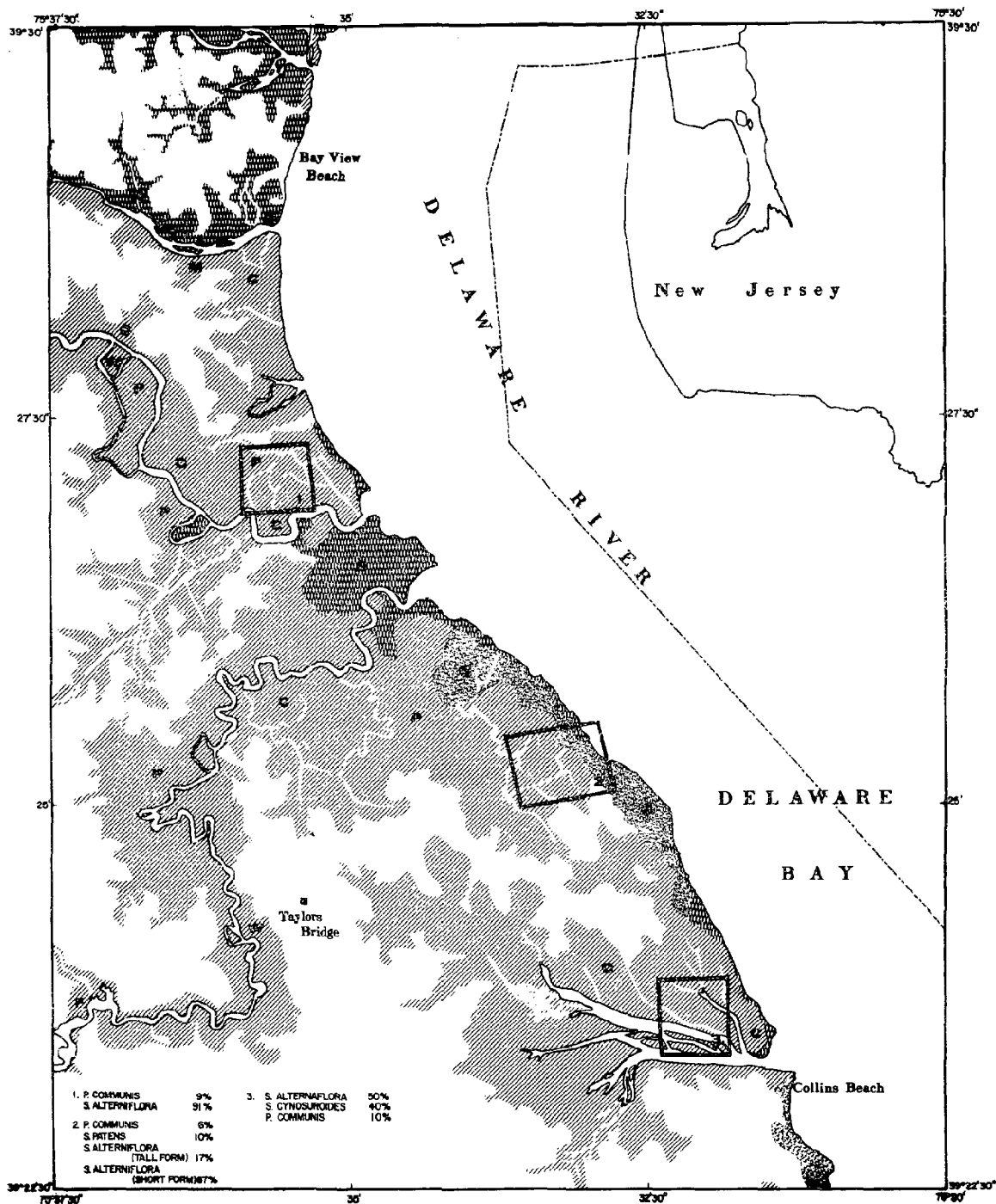


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1832, Polyconic Projection.
Vegetation Mapped and Published by the College of Marine Studies College of Marine Studies, University of Delaware, Newark, Delaware 19711

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis palmifolia* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh land to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



1. P. COMMUNIS	9%	3. S. ALTERNIFLORA	50%
S. ALTERNIFLORA	51%	S. CYNOSUROIDES	40%
2. P. COMMUNIS	6%	P. COMMUNIS	10%
S. PATENS	10%		
S. ALTERNIFLORA			
(TALL FORM) 17%			
S. ALTERNIFLORA			
(SHORT FORM) 67%			

LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Scrub (*Iva frutescens* and *Baccharis halimifolia*)
- S. *Scirpus* spp.
- M. *Mibiscus* spp.
- Z. *Zizania aquatica*
- N. *Acrida canadensis*
- F. Fresh Water *Glyceria* (*Peltandra virginica*, *Pontederice cordata*, *Typha* spp., *Sagittaria* spp.)

TAYLORS BRIDGE, DEL.

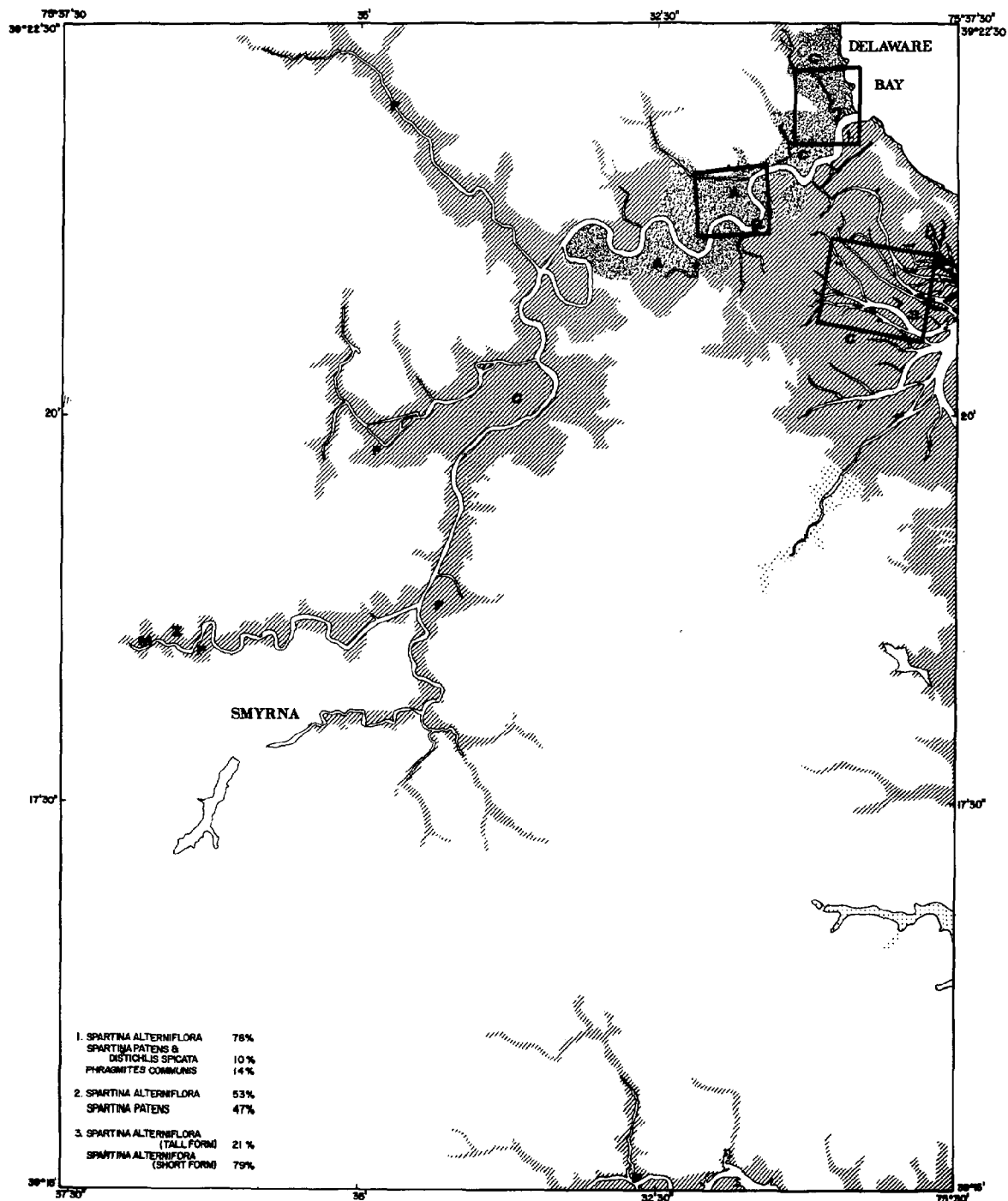


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1933, Polyconic Projection.
Vegetation Mapping and Published by the College of Marine Studies College of Marine Studies, University of Delaware, Newark, Delaware 19711
P. 100, 1000000, 1:100000, 1:100000

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis halimifolia* (High Marsh Scrub)
- Impounded Fresh Water
- Marsh lost to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- F. *Phragmites communis*
A. *Spartina alterniflora*
C. *Spartina cynosuroides*
H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
I. Shrubs (the *Fragaria* and *Baccharis halimifolia*)
S. *Scirpus* spp.
M. *Hibiscus* spp.
Z. *Zizania aquatica*
W. *Azadirachta indica*
F. Fresh Water *Carex* (*Potamogeton* spp., *Potamogeton* spp., *Potamogeton* spp.)



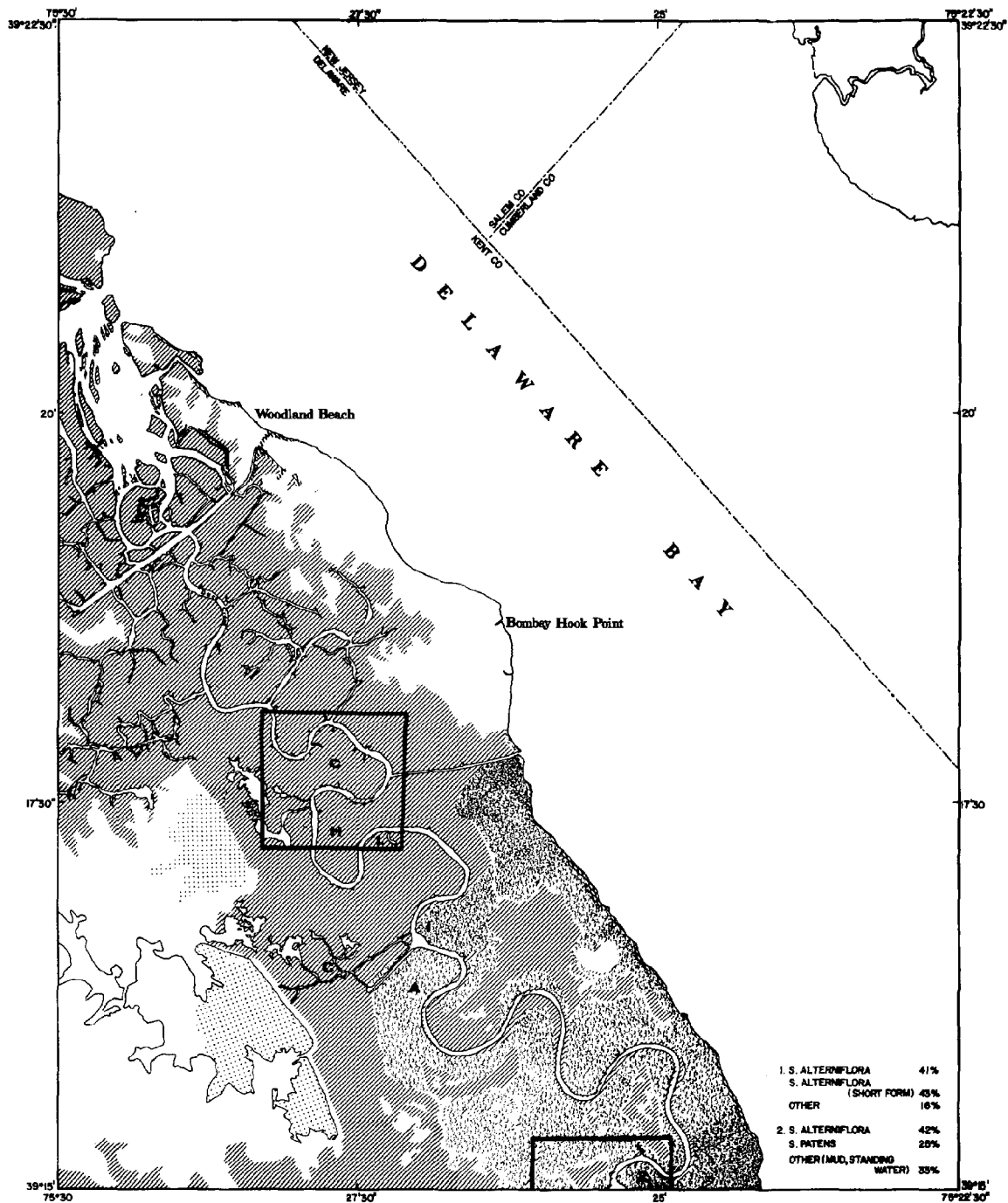
SMYRNA, DEL.

VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1933, Polyconic Projection
Vegetation Mapped and Published by the College of Marine Studies, University of Delaware, Newark, Delaware 19711
Scale 1:50,000 (1:50,000 S.L. 1971)

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis (Reed Grass)
Spartina alterniflora (Salt Marsh Cord Grass)
Spartina patens and Distichlis spicata (Salt Hay)
The *Fragaria* and *Baccharis halimifolia* (High Marsh Shrubs)
Pondweed Fresh Water
Marsh land to development and/or dredge spoil since 1950 (topographic map revision)
Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- N. Salt Mar (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (*Iva frutescens* and *Baccharis halimifolia*)
- S. *Spartina* spp.
- M. *Phragmites* spp.
- Z. *Zostera aquatica*
- W. *Acrida canadensis*
- F. Fresh Water Category (*Peltandra virginica*, *Potamogeton nodosus*, *Typha* spp., *Sagittaria* spp.)



BOMBAY HOOK, DEL.

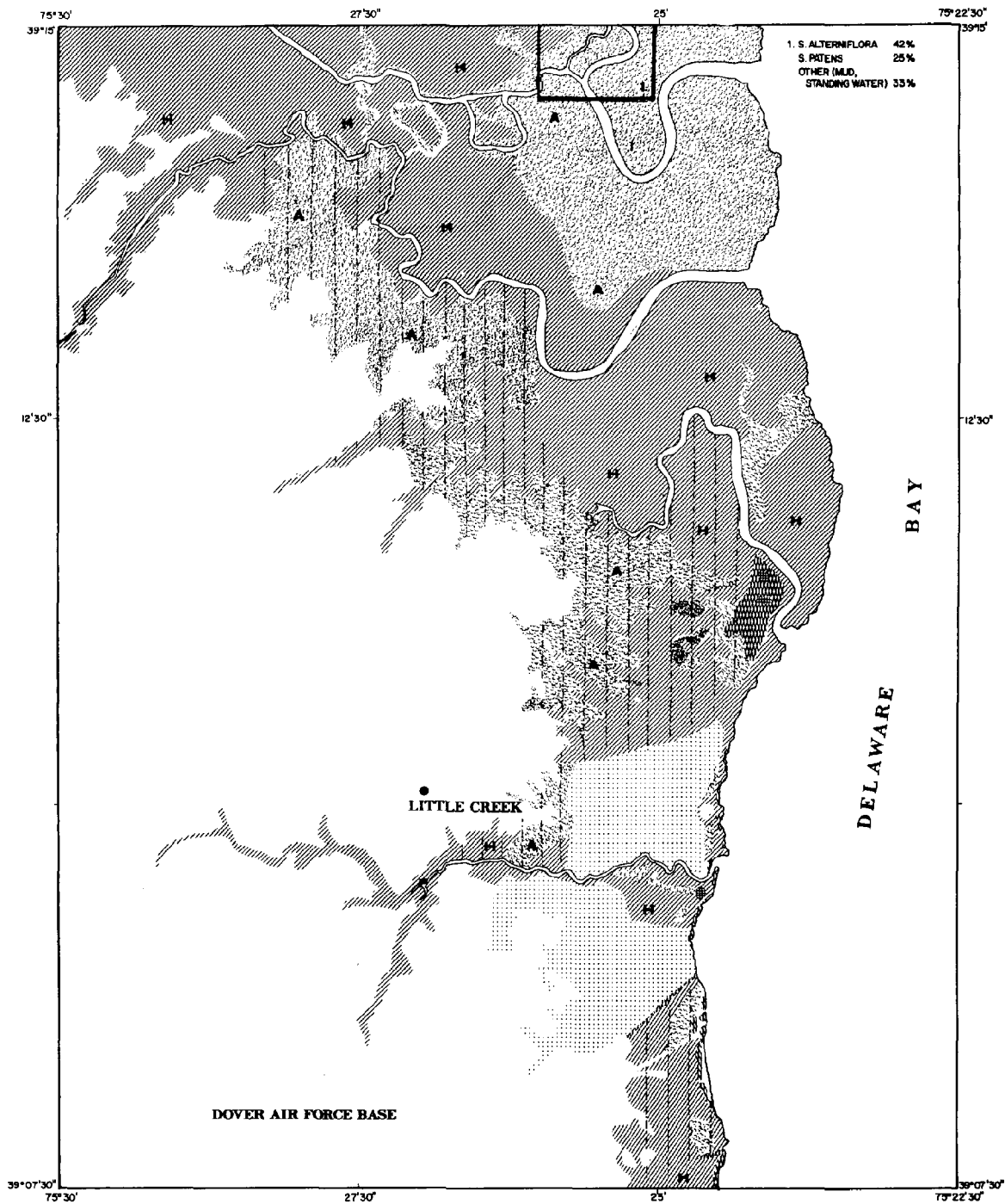


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series V832, Potomac Projection.
Vegetation Mapping and Published by the College of Marine Studies, College of Marine Studies, University of Delaware, Newark, Delaware 19711

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis (Reed Grass)
- Spartina alterniflora (Salt Marsh Cord Grass)
- Spartina patens and Distichlis spicata (Salt Hay)
- Iva frutescens and Baccharis halimifolia (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh loss to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P *Phragmites communis*
 A *Spartina alterniflora*
 C *Spartina cynosuroides*
 H *Salt Hay (Spartina patens and Distichlis spicata)*
 I *Shrubs (Ilex frutescens and Baccharis halimifolia)*
 S *Salix* spp.
 M *Hibiscus* spp.
 Z *Zizania aquatica*
 W *Acrida canadensis*
 F *Fresh Water Category (Peltandra virginica, Pontedericea zosterifolia, Typha spp., Sagittaria spp.)*



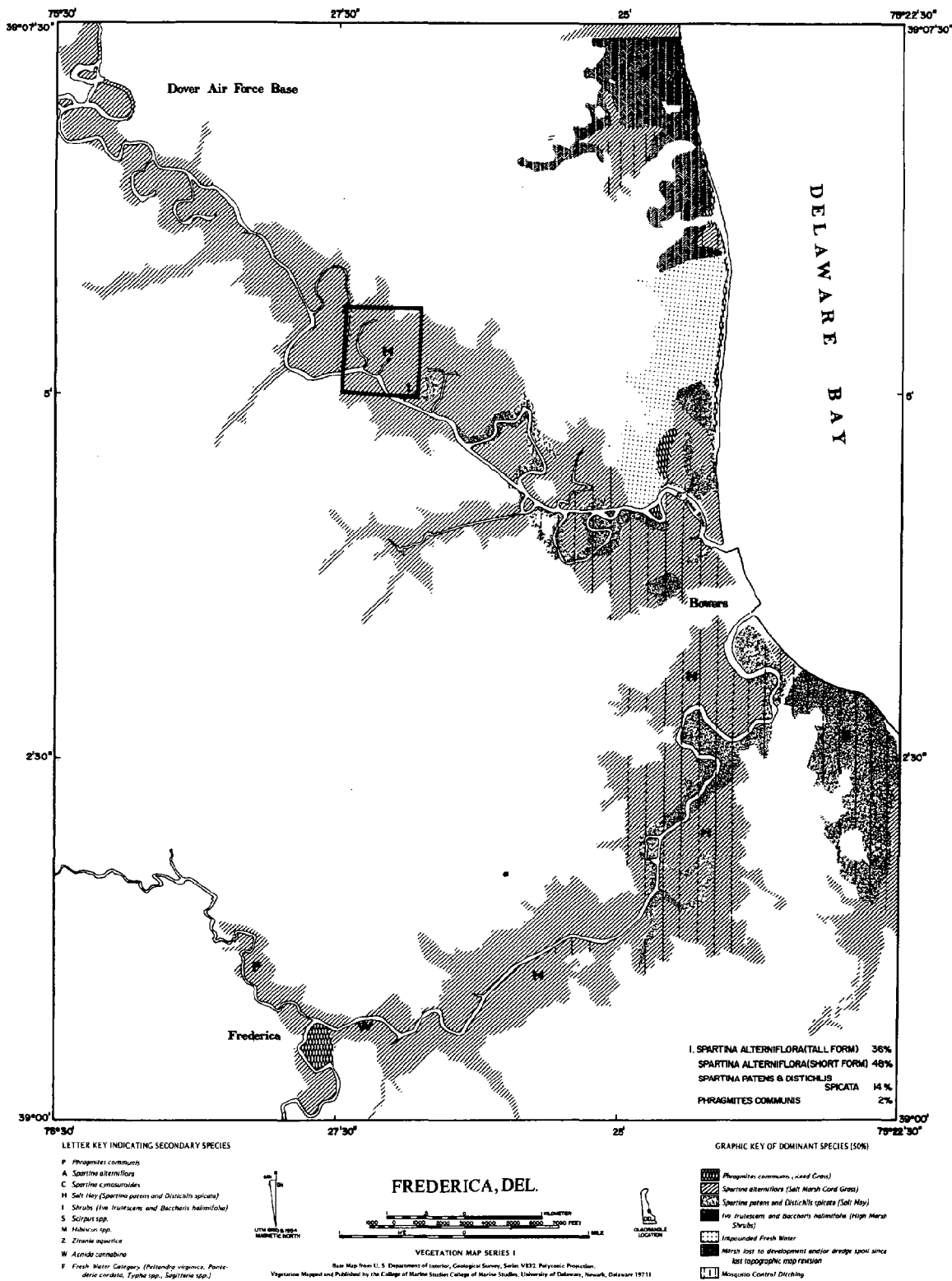
LITTLE CREEK, DEL.

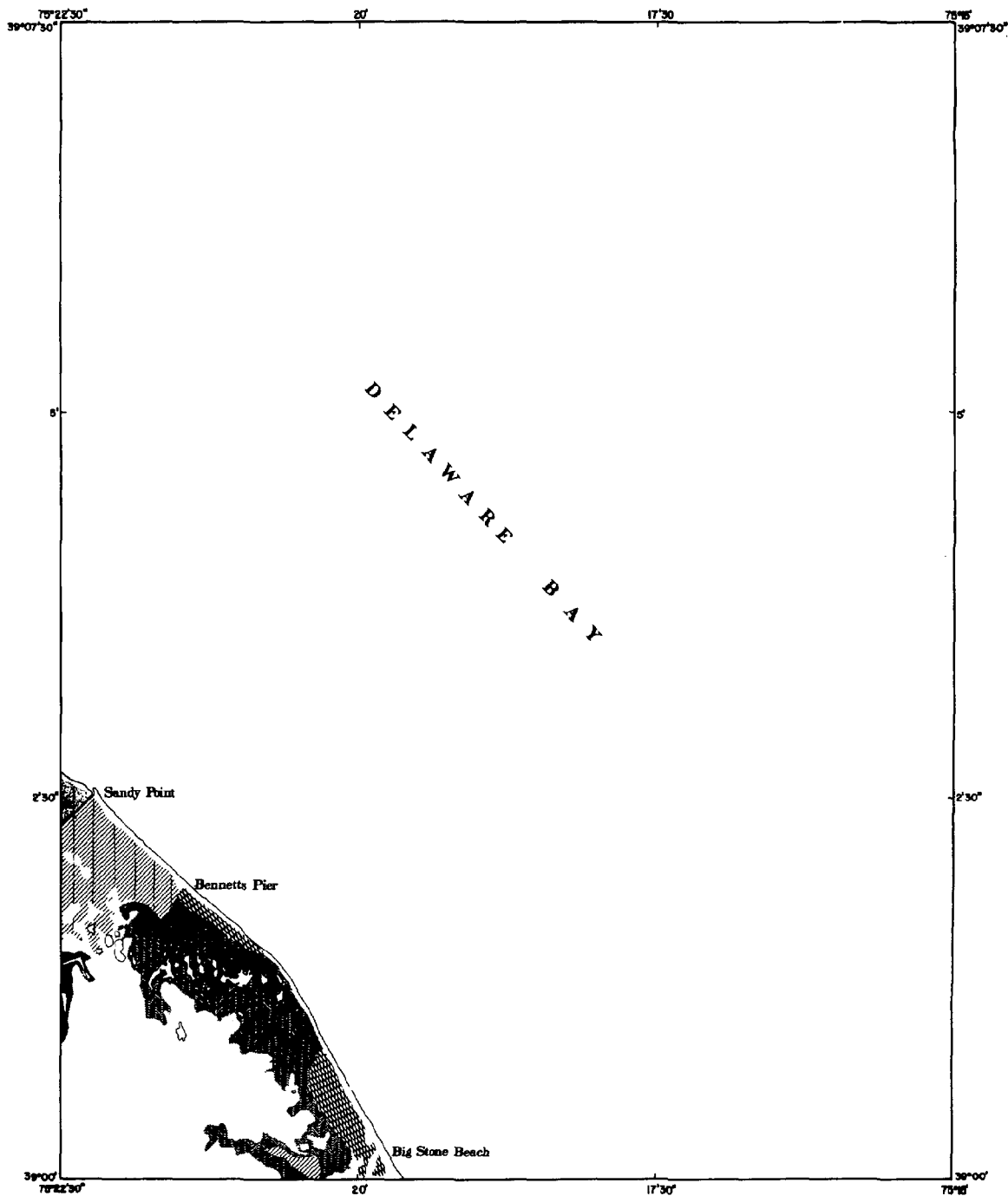
VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series YB2, Polyconic Projection.
 Vegetation Mapped and Published by the College of Marine Studies, College of Marine Studies, University of Delaware, Newark, Delaware 1971.
 MAP SCALE: 1:25,000 (1" = 200 FEET)

GRAPHIC KEY OF DOMINANT SPECIES (S1-S30)

- S1 *Phragmites communis* (Reed Grass)
 S2 *Spartina alterniflora* (Salt Marsh Cord Grass)
 S3 *Spartina patens and Distichlis spicata* (Salt Hay)
 S4 *Ilex frutescens and Baccharis halimifolia* (High Marsh Shrubs)
 S5 *Salix* spp.
 S6 *Hibiscus* spp.
 S7 *Zizania aquatica*
 S8 *Acrida canadensis*
 S9 *Peltandra virginica*
 S10 *Pontedericea zosterifolia*
 S11 *Typha* spp.
 S12 *Sagittaria* spp.
 S13 *Impounded Fresh Water*
 S14 *Marsh area in development and/or dredge spoil since last topographic map revision*
 S15 *Mosquito Control Discharge*





LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (*Iva frutescens* and *Baccharis halimifolia*)
- S. *Scrubus* spp.
- M. *Hibiscus* spp.
- Z. *Zostera aquatica*
- W. *Arundo donax*
- F. Fresh Water Category (*Peltandra virginica*, *Pontederia cordata*, *Typha* spp., *Sagittaria* spp.)



BENNETTS PIER, DEL.

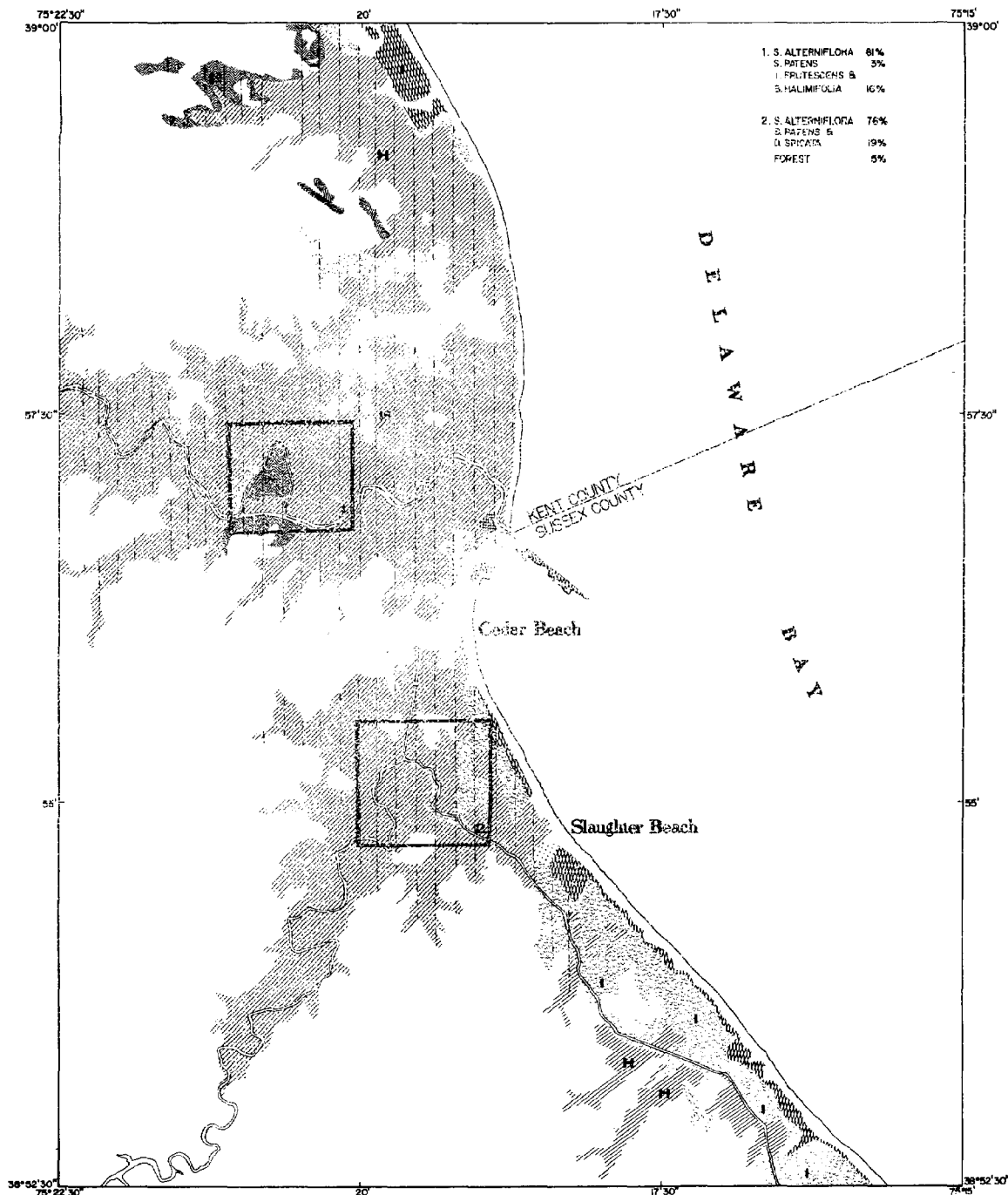


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1933, Photocopy Projection.
Vegetation Mapped and Published on the College of Marine Studies, University of Delaware, Newark, Delaware 19711.
1971, 1972, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis halimifolia* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh lost to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (*Iva frutescens* and *Baccharis halimifolia*)
- S. *Scirpus spp.*
- M. *Muhlenbergia spp.*
- Z. *Zizania aquatica*
- W. *Alnida canadensis*
- F. Fresh Water Category (*Peltandra virginica*, *Pontederice cordata*, *Typha* spp., *Sagittaria* spp.)



MISPILLION RIVER, DEL.

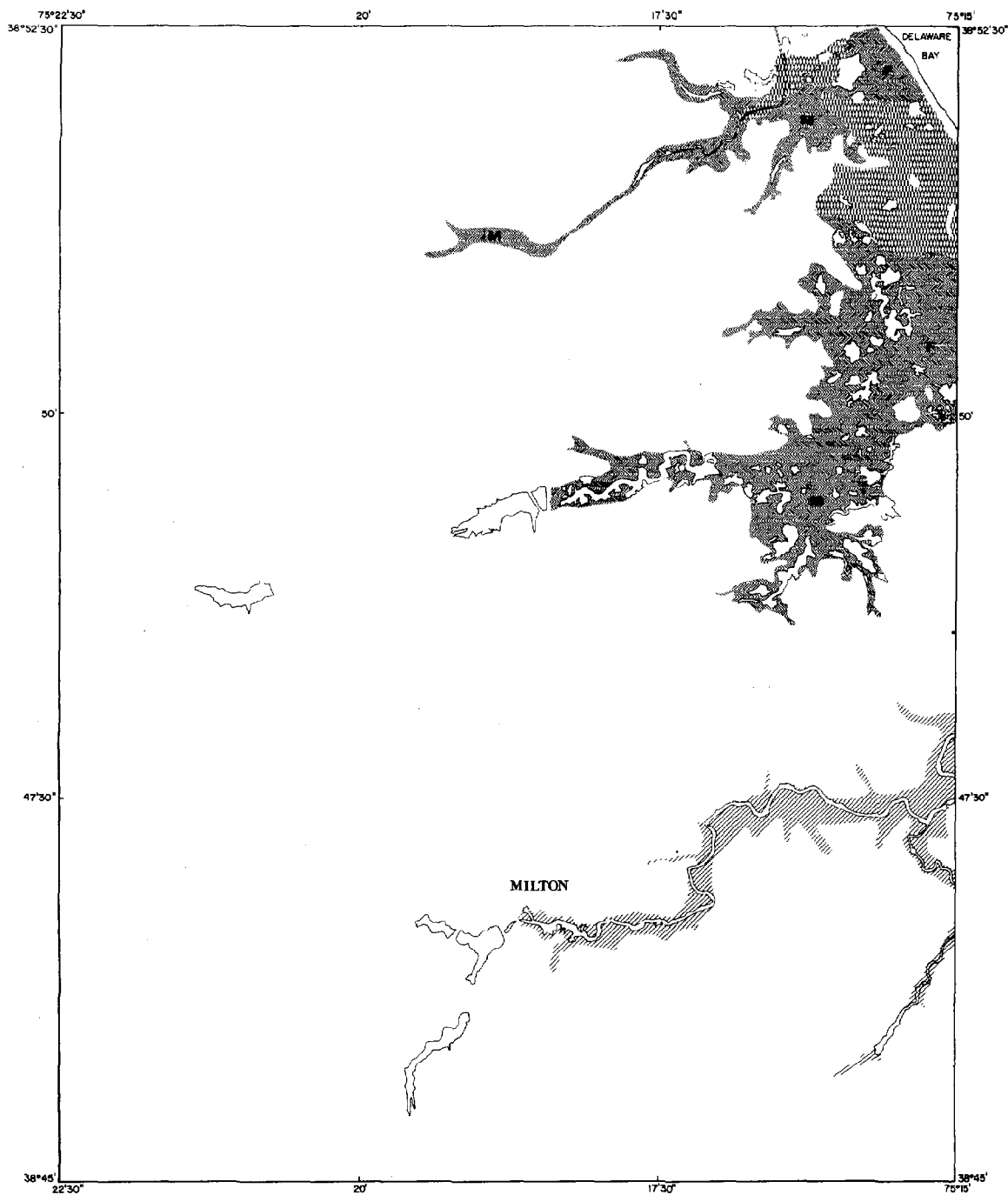


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Ecological Survey, Series V812 Polyconic Projection.
Vegetation Mapped and Published by the College of Marine Studies, University of Delaware, Newark, Delaware (1971)
Photo Courtesy: T. B. Smith & Co. Inc.

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis halimifolia* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh lost to development and/or dredge spoil site but topographic map revision
- Mosquito Control Ditching

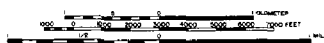


LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. *Scirpus (Iva frutescens and Iva xanthophylla)*
- S. *Scirpus*
- M. *Hibiscus* spp.
- Z. *Zinnia mexicana*
- W. *Arundo donax*
- F. *Ficus* (Banyan: *Ficus religiosa*, *Ficus religiosa*, *Ficus religiosa*)



MILTON, DEL.

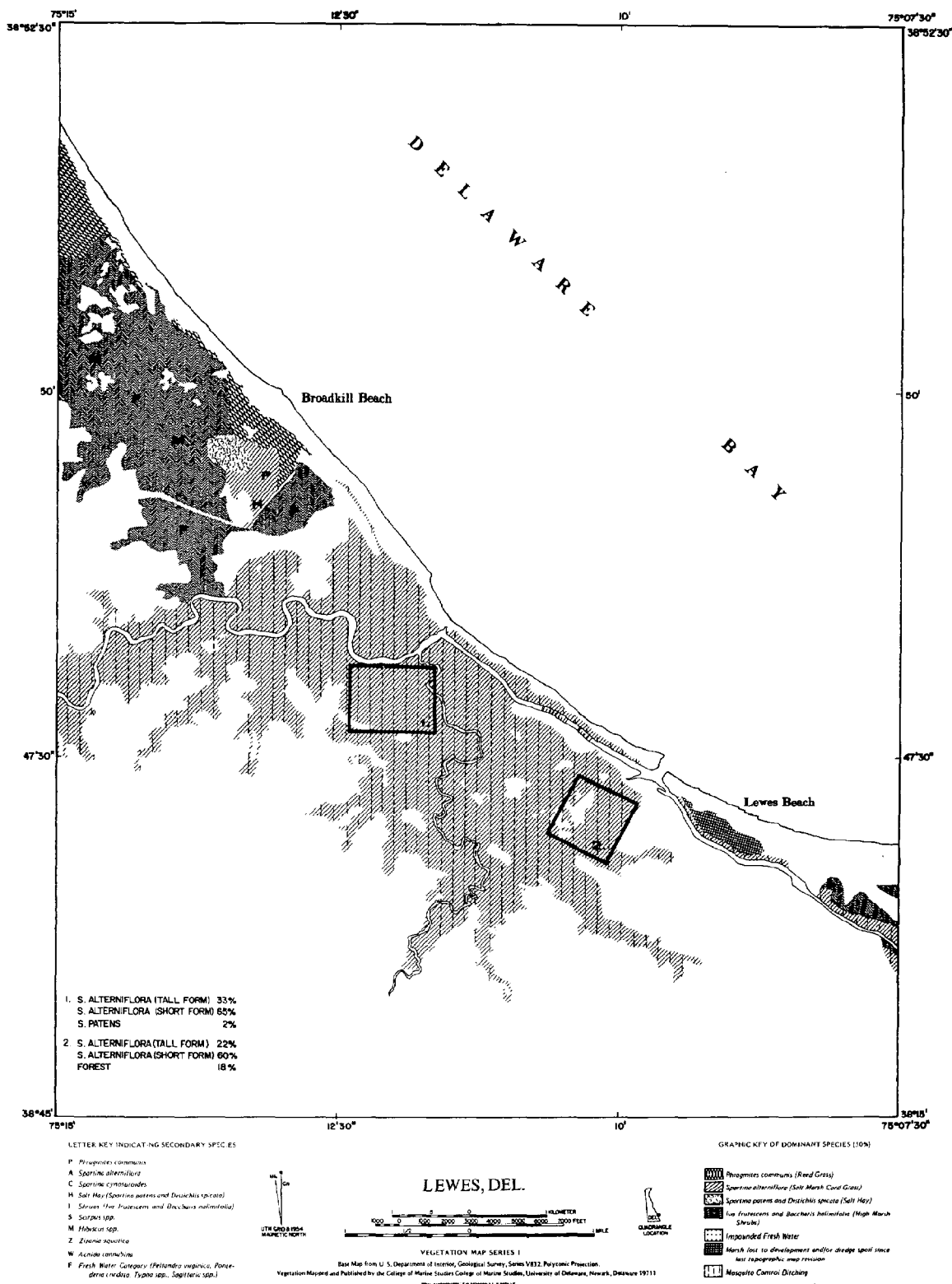


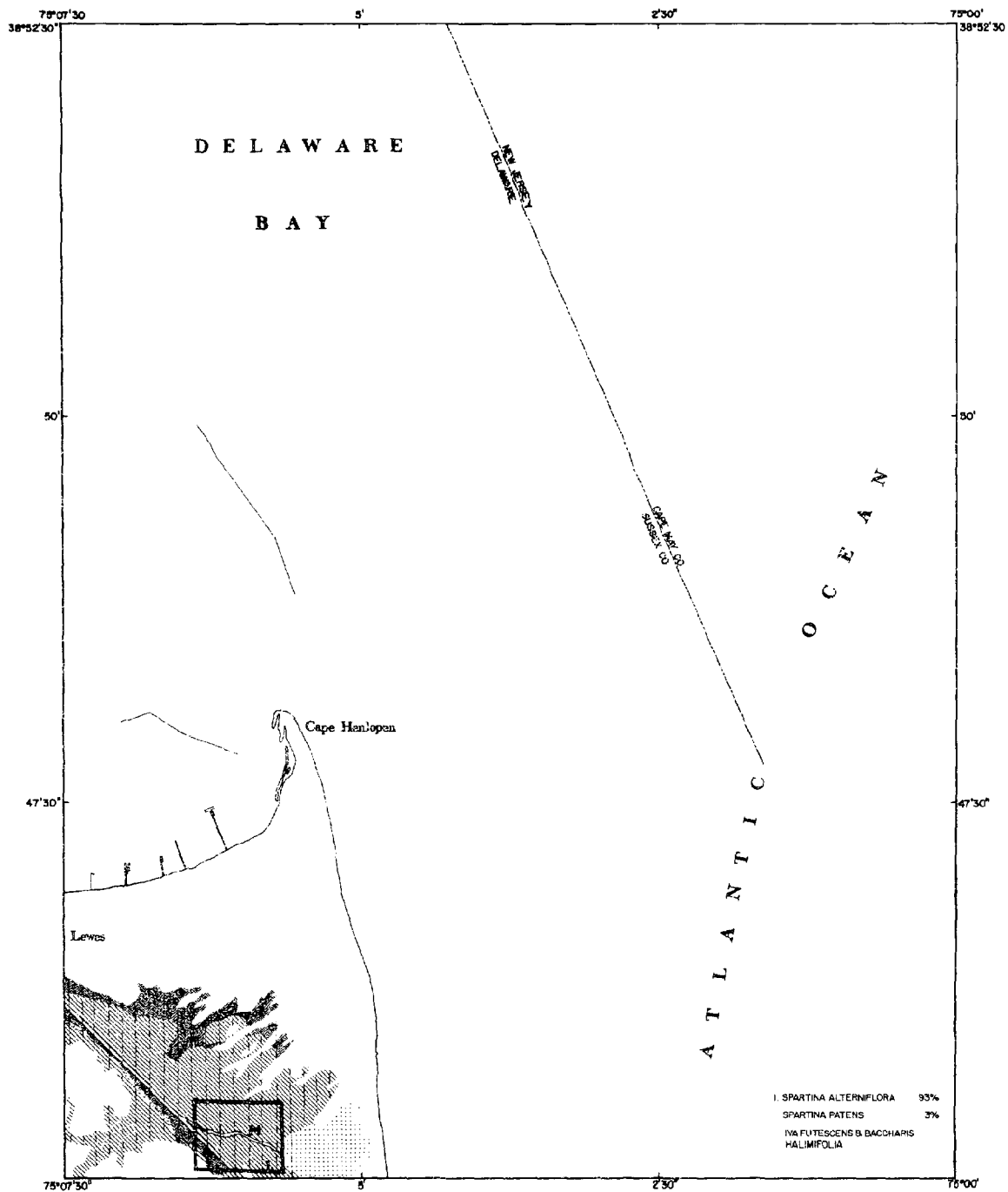
VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series V-82, *Religious, Protestant*
 Vegetation Map and Published by the College of Marine Studies, College of Marine Studies, University of Delaware, Newark, Delaware 19711
 This vegetation is a composite of the following:

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Breed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina cynosuroides* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Iva xanthophylla* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh lost to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching





LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Baccharis spicata*)
- I. Shrub (*Iva frutescens* and *Baccharis halimifolia*)
- S. *Scirpus* spp.
- M. *Melaleuca* spp.
- Z. *Zizania aquatica*
- W. *Arundo donax*
- F. Fresh Water Cudweed (*Peltandra virginica*, *Pontederia cordata*, *Typha* spp., *Sagittaria* spp.)

CAPE HENLOPEN, DEL.

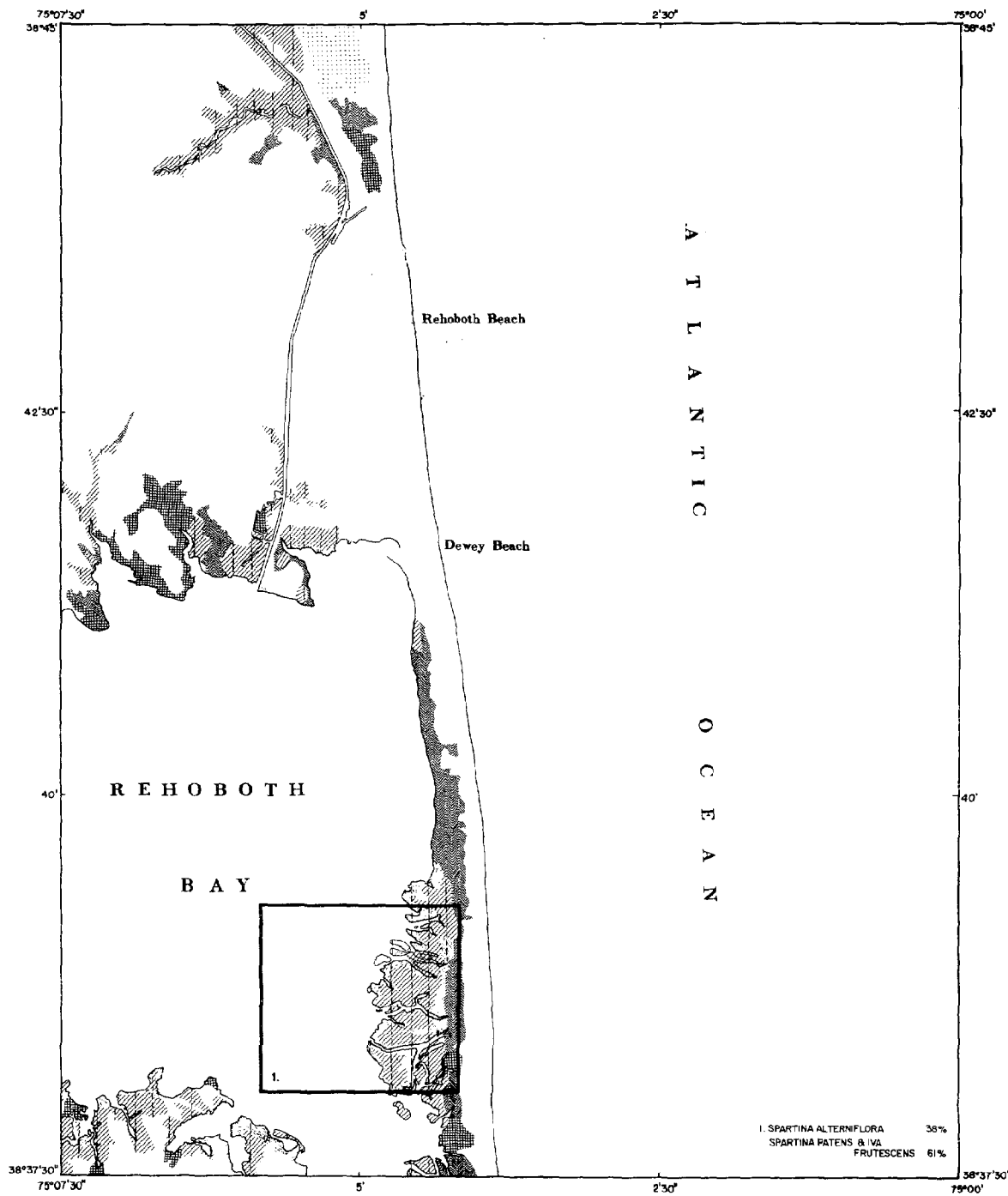


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1912, Photocopy Projection.
Vegetation Mapping and Publication by the College of Marine Studies, College of Marine Studies, University of Delaware, Newark, Delaware 19711.
From: *Vegetation of a portion of Delaware Bay*

GRAPHIC KEY OF DOMINANT SPECIES (SPR)

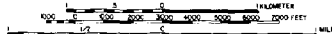
- Phragmites communis* (Rigid Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Baccharis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis halimifolia* (Widge Marsh Shrub)
- Impounded Fresh Water
- Marsh lost to development and/or dredge spoil since 1950 (Superior) (Wedge)
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (see *frutescens* and *Baccharis halimifolia*)
- S. *Scirpus* spp.
- M. *Filicaria* spp.
- Z. *Zizania aquatica*
- W. *Acrida canabina*
- F. Fresh Water Category (*Peltandra virginica*, *Potamogeton nodosus*, *Typha* spp., *Sagittaria* spp.)

REHOBOTH BEACH, DEL.

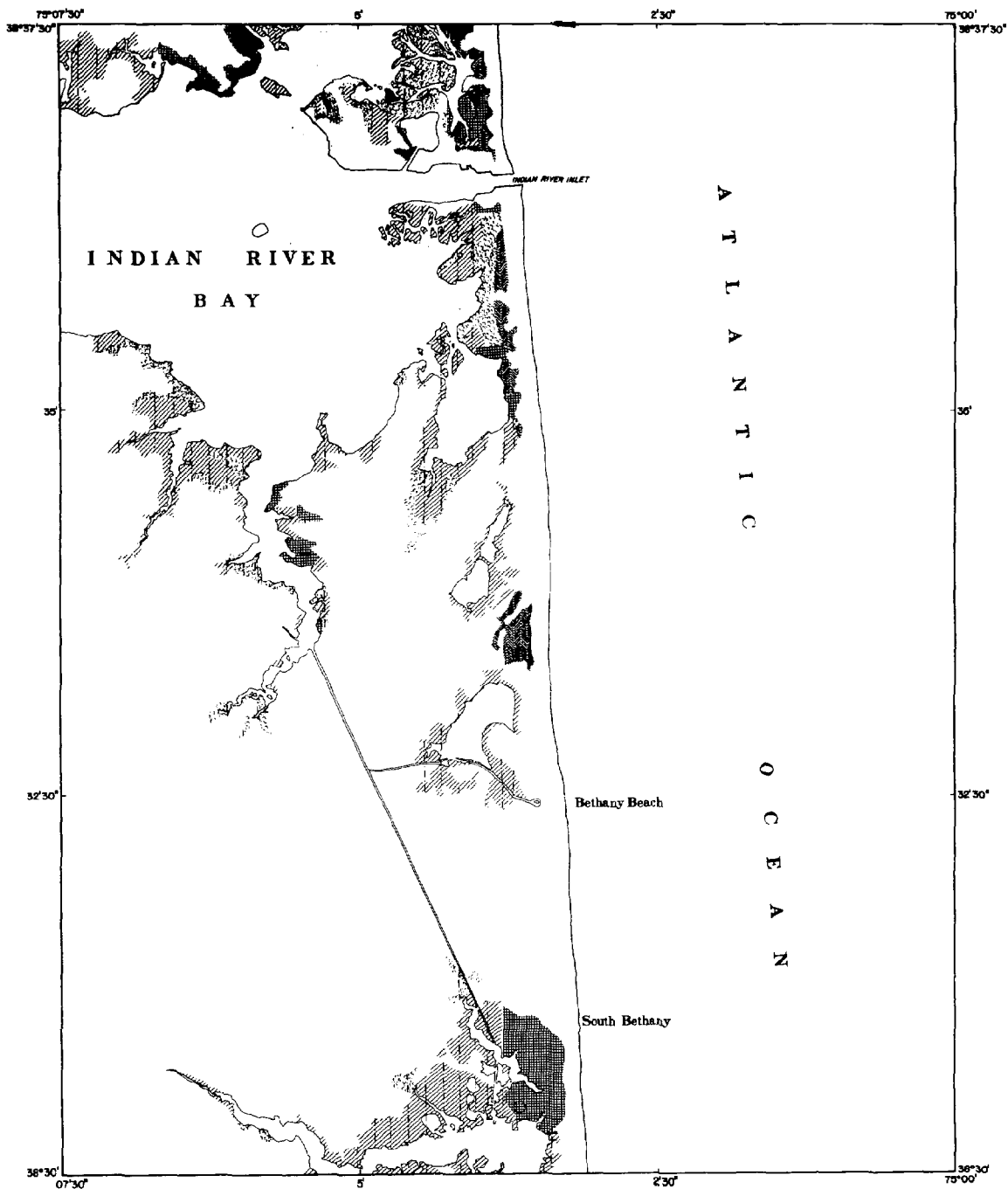


VEGETATION MAP SERIES 1

Base Map from U. S. Department of Interior, Geological Survey, Series 1:11, Paleogeographic Reconstructions of the Eastern United States, 1927-1928. Vegetation Mapping and Published in the College of Marine Studies, University of Delaware, Newark, Delaware 19711.

GRAPHIC KEY OF DOMINANT SPECIES (See...)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis halimifolia* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh not to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (*Iva frutescens* and *Baccharis halimifolia*)
- S. *Scirpus* spp.
- M. *Hibiscus* spp.
- Z. *Zostera aquatica*
- W. *Acrida cincta*
- F. Fresh Water Category (*Peltandra virginica*, *Potamogeton nodosus*, *Typha* spp., *Sagittaria* spp.)



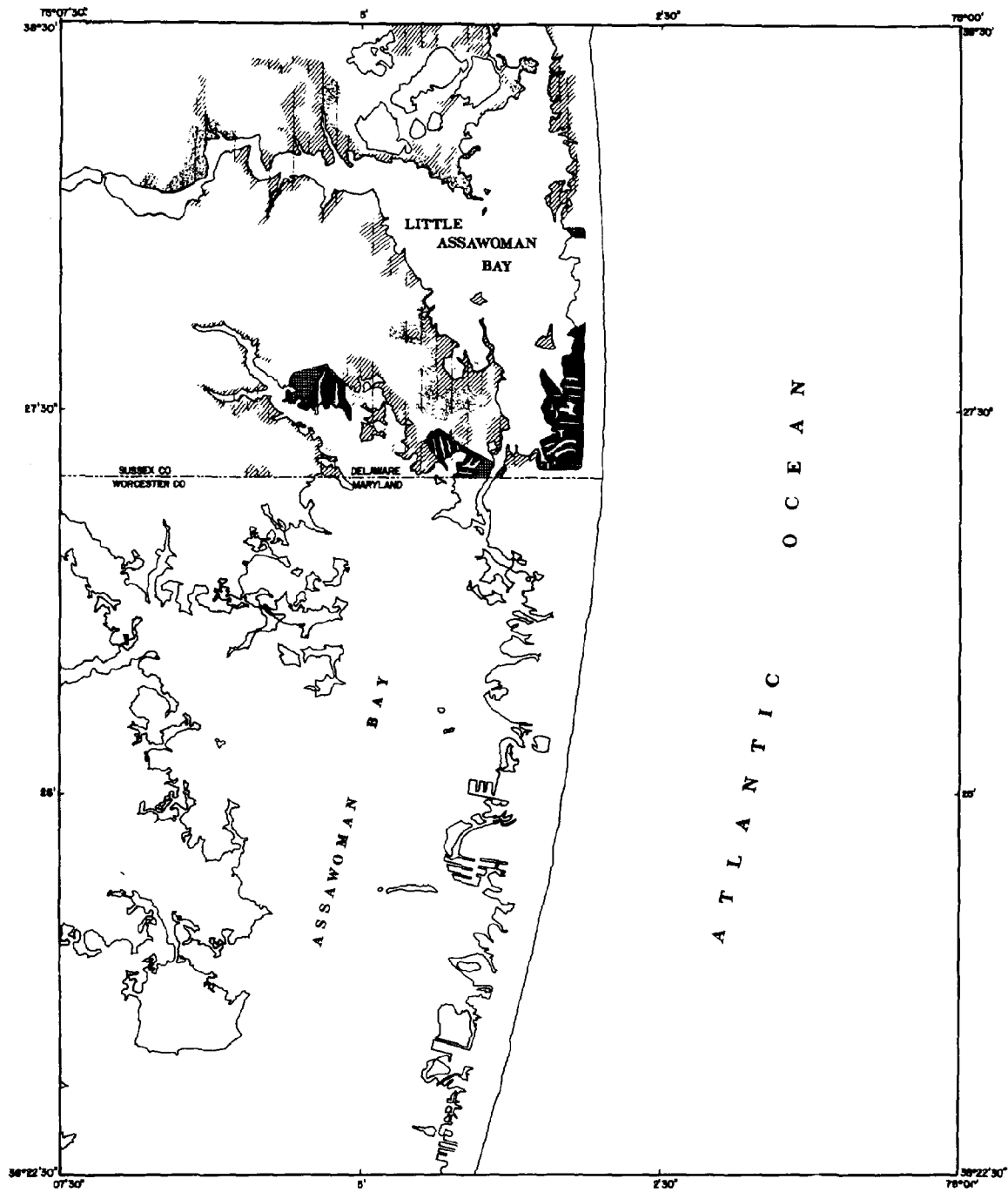
BETHANY BEACH, DEL.

VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey Series 1832, Polyconic Projection.
Vegetation Mapped and Published by the College of Marine Studies, University of Delaware, Newark, Delaware 19711

GRAPHIC KEY OF DOMINANT SPECIES (SPR)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva frutescens* and *Baccharis halimifolia* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh Not to development and/or dead since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. Salt Hay (*Spartina patens* and *Distichlis spicata*)
- I. Shrubs (The *Fraxinus* and *Baccharis tomentosa*)
- S. *Scirpus* spp.
- M. *Ichnusa* spp.
- Z. *Zizania aquatica*
- W. *Arundo donax*
- F. Fresh Water Cabbage (*Peltandra virginica*, *Peltandra cordata*, *Typha* spp., *Sagittaria* spp.)



ASSAWOMAN BAY, DEL.

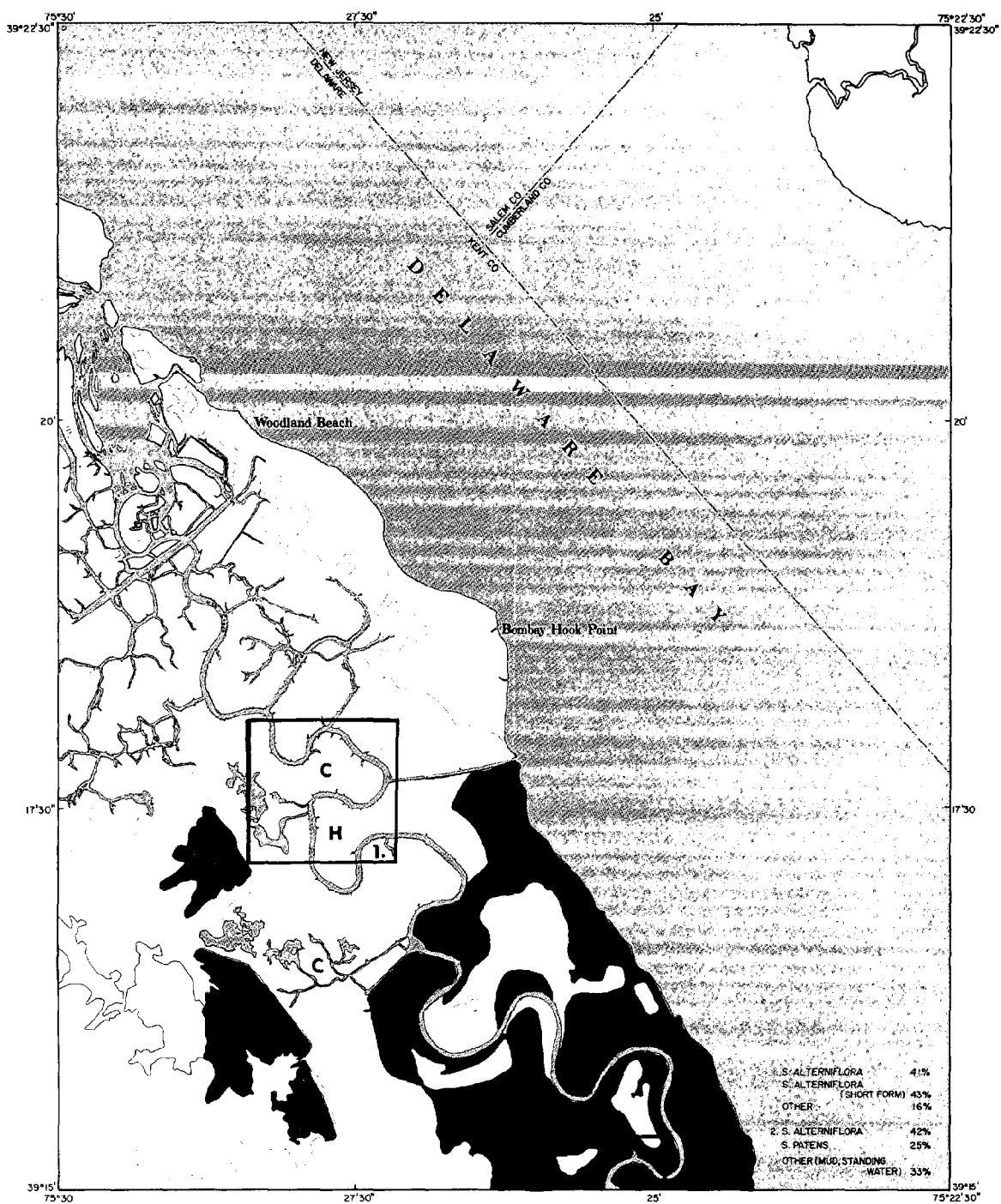


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1872, Polyconic Projection.
Vegetation Mapping and Published by the College of Marine Studies, College of Marine Studies, University of Delaware, Newark, Delaware 19711

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina cynosuroides* and *Distichlis spicata* (Salt Hay)
- Fraxinus* and *Baccharis tomentosa* (High Marsh Shrubs)
- Impounded Fresh Water
- Marsh lost to development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. *Spartina patens* and *Distichlis spicata*
- I. *Shrub (The Fraxinus and Baccharis halimifolia)*
- S. *Spartina* spp.
- M. *Miscanthus* spp.
- Z. *Zizania aquatica*
- W. *Alisma canaliculata*
- F. *Fresh Water Category (Peltandra virginica, Pontedericea zosterifolia, Typha spp., Sagittaria spp.)*



BOMBAY HOOK, DEL.

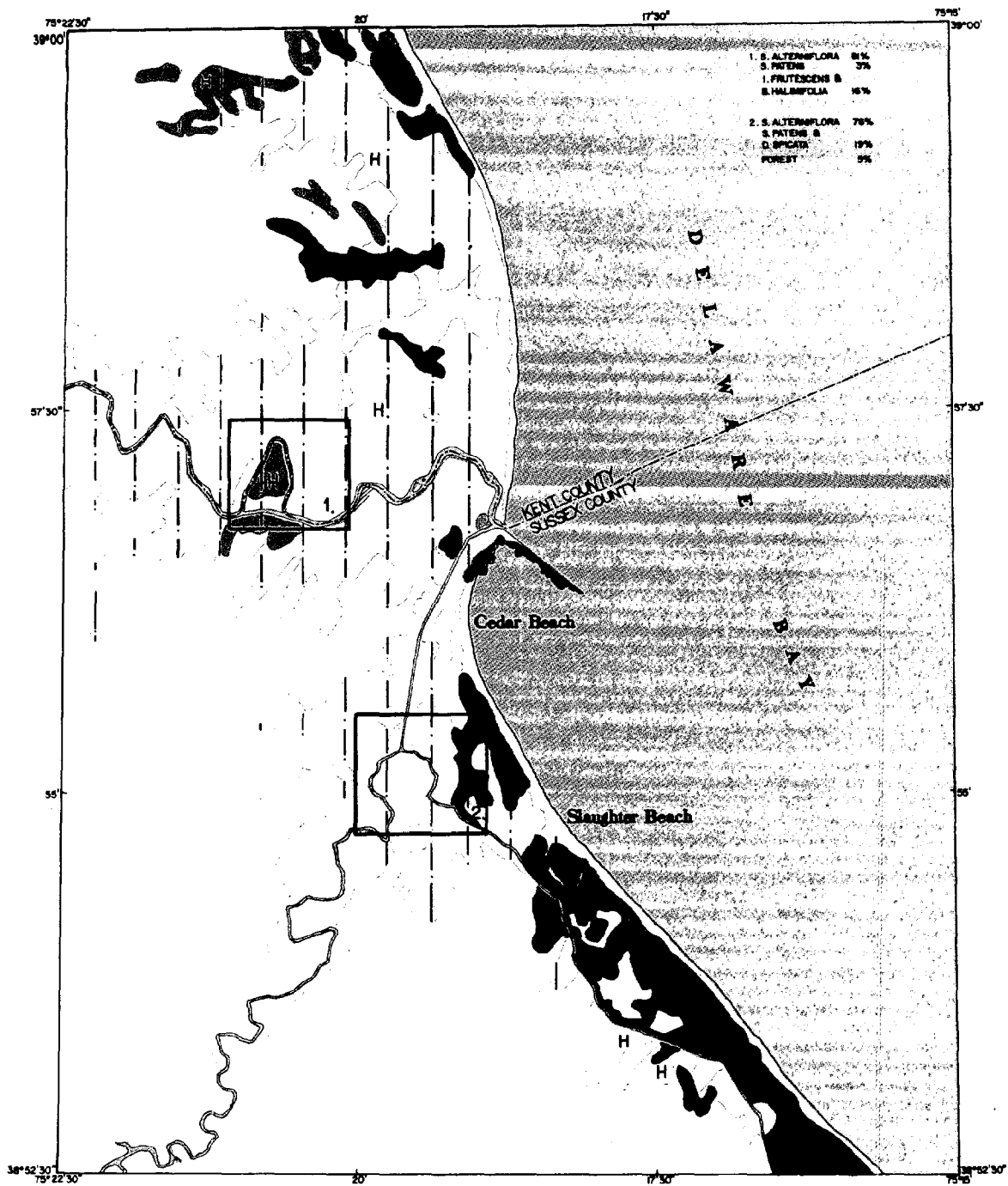


VEGETATION MAP SERIES I

Base Map from U. S. Department of Interior, Geological Survey, Series 1017, Polyconic Projection
Vegetation Map and Published by the College of Marine Studies, University of Delaware, Newark, Delaware 19711
Map coordinates in UTM 18SA 1000000

GRAPHIC KEY OF DOMINANT SPECIES (50%)

- Phragmites communis* (Reed Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Iva fraxinea* and *Baccharis halimifolia* (High Marsh Shrubs)
- Inland Fresh Water
- Marsh for no development and/or dredge spoil since last topographic map revision
- Mosquito Control Ditching



LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. *Spartina patens* and *Distichlis spicata*
- I. *Spartina patens* and *Distichlis spicata*
- S. *Spartina* spp.
- N. *Najas* spp.
- Z. *Zostera marina*
- W. *Acrostichum*
- F. *Firch Water* Category: *Perfoliatus virginicus*, *Portulaca oleraceus*, *Typha* spp., *Sagittaria* spp.



MISPILLION RIVER, DEL.



VEGETATION MAP SERIES I

Map from U. S. Department of Interior, Geological Survey, Series 1912, Potomac Projection. Vegetation Mapped and Published by the College of Marine Studies, University of Delaware, Newark, Delaware 19711.

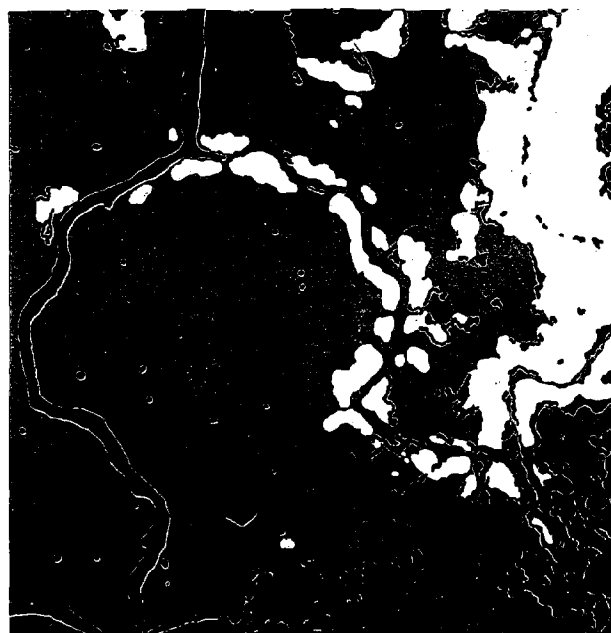
GRAPHIC KEY OF DOMINANT SPECIES (100%)

- Phragmites communis* (Reed Swamp)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)
- Spartina patens* and *Distichlis spicata* (High Marsh)

FIGURE 4



- A)
Enhancement of area
in box #1, Little Creek
Quad.
- Black - water and mud
- Blue - *S. patens* and *D. spicata*
- Yellow - *S. alterniflora*
and *S. cynosuroides*



- B)
Enhancement of area
in box #2, Mispillion
R. Quad.
- Black - water and forest
- Blue - *S. alterniflora*
- Yellow - *S. patens*

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